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ABSTRACT

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USE OF CLASSROOM ENVIRONMENT SCALE IN INVESTIGATING EFFECTS OF PSYCHOSOCIAL MILIEU ON SCIENCE STUDENTS' OUTCOMES

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Abstract

Relationships between student affective and cognitive learning outcomes and their perceptions of classroom environment as measured by the Classroom Environment Scale (CES) were investigated for a sample of 1,083 students in 116 science classrooms. It was found that CES scales displayed satisfactory internal consistency and discriminant validity, and that each CES scale differentiated significantly between the perceptions of students in different classrooms. Six different statistical analyses (simple correlation, multiple correlation, and canonical correlation analysis conducted separately for raw posttest scores and residual posttest scores adjusted for corresponding pretest and general ability) were used to investigate environment-outcome relationships. The results of these different analyses taken together confirmed the existence of sizable and statistically significant associations between student learning outcomes and their classroom environment perceptions as measured by the CES. In particular, greater levels of classroom Order and Organizations were linked with greater student achievement of several outcomes.

Over the last decade or so, researchers in several countries have shown increasing interest in the conceptualization, assessment, and investigation of a wide range of human milieus including family environments (Marjoribanks, 1979), physical environments (Proshansky, Ittleson, & Rivlin, 1970), college environments (Stern, 1970), psychiatric treatment environments (Moos, 1974a), and correctional and community environments (Moos, 1975). Evidence gleaned from past studies strongly supports the notion that the environment exerts considerable influence on human behavior and constitutes a major determinant of effective functioning and satisfaction among milieu inhabitants.

This interest in a variety of human environments has been accompanied by considerable interest in the study of the environments of school classrooms. A common feature of much of this research is that classroom environment has been assessed in terms of student perceptions of psychosocial dimensions. Work on student perceptions of their classroom environment has been summarized recently in a guest-edited journal issue (Fraser, 1980), several books (Fraser, 1981a; Moos, 1979; Walberg, 1979), and key literature reviews (Fraser, 1981b; Walberg, 1976; Walberg & Haertel, 1980). Furthermore, the comprehensiveness of Fraser and Walberg's (1981) recent review in Studies in Science Education reflects that classroom environment research currently is an active field of study among science education researchers.

An overview of previous research shows that the instrument used most frequently in studies of the environment of science classrooms has been the Learning Environment Inventory (Anderson & Walberg, 1974). In contrast, it appears that the Classroom Environment Scale (CES) (Moos & Trickett, 1974) has had little or no prior use specifically in science classes. Because the CES has had so little use in science education, a secondary purpose of

the present study was to explore the validity and usefulness of the CES in science education specifically.

The strongest tradition in past research has involved the investigation of relationships between the nature of the classroom environment and student achievement of valued aims in science education (Haertel, Walberg, & Haertel, 1981). The present research is consistent with this tradition as it provided the first use of the CES in science classrooms in studying associations between students' outcomes and their perceptions of classroom environment.

CLASSROOM ENVIRONMENT SCALE

Initial Development

One of the instruments used most extensively in prior classroom environment research is the Classroom Environment Scale (CES) (Moos & Trickett, 1974; Trickett & Moos, 1973). The CES was developed by Rudolf Moos of Stanford University and grew out of a comprehensive research program involving perceptual measures of a variety of human environments including psychiatric hospitals, prisons, university residences, and work milieus. Moos found that the same three general categories could be used in conceptualizing the individual dimensions characterizing diverse psychosocial environments (Insel & Moos, 1974: Moos, 1974b). These three categories are Relationship Dimensions, which identify the nature and intensity of personal relationships within the environment and assess the extent to which people are involved in the environment and support and help each other, Personal Development Dimensions, which assess the basic directions along which personal growth and self-enhancement tend to occur, and System Maintenance and System Change Dimensions which involve the extent

to which the environment is orderly, clear in expectations, maintains control, and is responsive to change. The development of the CES was based on the above conceptual framework for psychosocial environments.

The final version of the CES was developed after field testing and modifying several preliminary versions. It consists of nine scales with 10 items of True-False response format in each scale (Moos & Trickett, 1974; Trickett & Moos, 1973). Table I clarifies the nature of the CES by listing the name of each scale and its classification according to Moos's scheme. and by providing a scale description and sample item for each scale.

Uses of the CES in the U.S.A. have shown that each of its nine scales differentiated significantly between classrooms (Moos & Trickett, 1974), and have established relationships of classroom perceptions to student satisfactions and moods (Trickett & Moos, 1974) and to student absences and grades (Moos & Moos, 1978). Furthermore, Kaye, Trickett, and Quinlan (1976) have reported significant relationships among the various methods of assessing classroom environments, including student perceptions (using the CES), ratings by outside observers, and content analysis of teacher-student verbal interactions. Also, using the CES, revealing differences have been found between types of classes classified according to Holland's scheme (realistic, investigative, social, conventional, enterprising, artistic) (Hearn & Moos, 1978),

Table 1. Descriptive Information for Each Scale of CES

Scale Name	Moos's General Category	Scale Description Extent to which ...	Sample Item
Involvement	Relationship	... students have attentive interest, participate in discussions, do additional work, and enjoy the class.	Students daydream a lot in this class. (-)
Affiliation	Relationship	... students help each other, get to know each other easily, and enjoy working together.	Students in this class get to know each other really well. (+)
Teacher Support	Relationship	... the teacher helps, befriends, trusts, and is interested in students.	The teacher takes a personal interest in the students. (+)
Task Orientation	Personal Development	... it is important to complete activities planned and to stay on the subject matter.	The teacher often takes time out from the lesson plan to talk about other things. (-)
Competition	Personal Development	... students compete with each other for grades and recognition.	Some students always try to see who can answer questions first. (+)
Order and Organization	System Maintenance & System Change	... there is emphasis on students behaving in an orderly, quiet, and polite manner, and on the overall organization of classroom activities.	Assignments are usually clear so everyone knows what to do. (+)
Rule Clarity	System Maintenance & System Change	... rules are clear, students know the consequence of breaking rules, and the teacher deals consistently with students who break rules.	There is a clear set of rules for students to follow. (+)
Teacher Control	System Maintenance & System Change	... rules are enforced and rule infractions are punished.	Students don't always have to stick to the rules in this class.(-)
Innovation	System Maintenance & System Change	... the teacher plans new, unusual, and varying activities and techniques, and encourages students to contribute to classroom planning and to think creatively.	New and different ways of teaching are not tried very often in this class. (-)

Items designated (+) were scored 3 and 1, respectively, for the responses of True and False. Items designated (-) were scored in the reverse manner. Omitted or invalid responses were scored 2.

and between classes in five different types of schools (urban, rural, suburban, vocational, alternative) (Trickett, 1978).

Validation with Present Sample

The present study involved administration of the CES to a representative sample of 116 grade 8 and 9 science classes, each with a different teacher, in 33 schools in Tasmania, Australia. Schools were located in both suburban and country areas and approximately equal numbers of boys and girls made up the sample. As only a random half of each class responded to the CES (while the rest of the class simultaneously answered other questionnaires for another purpose), the total number of students in the sample was 1,083. Since the intact class and not the individual student was the primary sampling unit, it was decided to employ the class mean as the unit of statistical analysis throughout the study (see Ross, 1978). The advantage of using the class mean in this context is that it satisfies the requirement of independence of observations.

Because very little information is available elsewhere about the reliability and validity of the CES when used with a sample of science classes, Table II reports some validation data for the sample of 116 Australian classes. These data include estimates of each scale's internal consistency reliability (alpha coefficient) and discriminant validity (mean magnitude of the correlation of a scale with the other eight scales) when the class mean was used as the unit of analysis. Class reliabilities were calculated simply by using the variance of class means in conjunction with the conventional alpha formula.

Table II. Internal Consistency (Alpha Coefficient) and Discriminant Validity (Mean Correlation with other Eight Scales) for Class Means, and ANOVA Results (F and Eta^2) for Class Membership Differences for each CES Scale

Scale	Scale Validation Statistics		ANOVA Results	
	Alpha Reliability	Mean Correlation with Other Scales	F	Eta^2
Involvement	0.81	0.42	3.38**	0.29
Affiliation	0.71	0.29	2.17**	0.21
Teacher Support	0.85	0.38	4.40**	0.34
Task Orientation	0.72	0.31	2.81**	0.25
Competition[a]	0.60	0.08	1.87**	0.18
Order & Organization	0.90	0.40	6.27**	0.43
Rule Clarity	0.76	0.36	2.21**	0.21
Teacher Control	0.71	0.23	3.07**	0.27
Innovation[a]	0.71	0.29	2.97**	0.26

** $p < .01$

Eta^2 is the ratio of between to total sums of squares and indicates the proportion of variance explained by class membership

Reliabilities and mean correlations are based on a sample of 116 class means. ANOVA results are for 1,083 students in the 116 classes

[a]Data are based on scales containing 10 items except for Competition (8 items) and Innovation (9 items).

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Data in Table II indicate that scale reliability estimates ranged from 0.60 to 0.90, thus indicating satisfactory internal consistency on each CES scale when using classes as the units of analysis. Table II also shows that the value of the mean correlation of a scale with the other scales ranged from 0.08 to 0.42, thus suggesting that the CES measures distinct although somewhat overlapping dimensions of classroom environment. Moreover, these data for the Australian sample compare favorably with those reported for a sample in the U.S.A. (Moos & Trickett, 1974), where internal consistency estimates ranged from 0.67 to 0.86 for a sample of 22 classes and mean correlations of a scale with the other scales ranged from 0.18 to 0.37 for a sample of 465 individual students.

A desirable characteristic of any classroom environment scale is that it is capable of differentiating between the perceptions of students in different classrooms. That is, students within the same class should perceive it relatively similarly, while mean within-class perceptions should vary from classroom to classroom. This characteristic was explored for each CES scale with the present sample by performing a one-way ANOVA, with class membership as the main effect and using the individual as the unit of analysis, to obtain information about the ratio of between-class variance to within-class variance. The results of these analyses are included in Table II and indicate that each CES scale differentiated significantly ($p < .01$) between the perceptions of students in different classrooms. Furthermore, the eta^2 statistic, which is the ratio of between to total sums of squares (Cohen & Cohen, 1975), was calculated as an estimate of the amount of variance in CES scores attributable to class membership. Table II shows that the proportion of variance accounted for by class membership ranged from 0.18 for the Competition scale to 0.43 for the Order and Organization scale.

RELATION OF CLASSROOM ENVIRONMENT TO STUDENT OUTCOMES

Prior Research

Prior research into associations between student outcomes and classroom environment perceptions exhibits many methodological variations in terms of choice of types of student outcomes, units of statistical analysis, methods of data analysis, and control for student background variables (see reviews of Fraser, 1981a; Haertel, Walberg, & Haertel, 1981). In particular, the three main methods of analysis commonly used have been a simple correlational analysis of relationships between individual outcome measures and individual environment scales, a multiple regression analysis of relationships between each outcome measure and the set of environment scales as a whole, and a canonical analysis of relationships between the set of outcomes and the set of environment scales. Another important methodological way in which prior studies differ is in terms of whether student background characteristics (particularly corresponding pretest outcome performance and general ability) were controlled statistically when estimating the strength of outcome-environment relationships.

It is interesting to review prior predictive validity studies specifically involving the use of the CES in order to summarize their conclusions and to highlight their methodological attributes. Trickett and Moos (1974) used the CES to explore relationships between student perceptions and their satisfactions and moods among a sample of 608 students in the U.S.A. in two matched groups of 18 classes from 18 different high schools. When simple correlations between CES and raw criterion scores were calculated separately for the two matched groups using the class as the unit of analysis, the number of statistically significant correlations was six times that expected by chance. In another study involving a sample of 19 high school classes in one school in the U.S.A., Moos and Moos (1978) used the CES to investigate associations between environment perceptions and student absences and grades. A simple correlational

analysis using the class mean as the unit of analysis revealed that the number of significant relationships between an outcome and one of the nine environment scales was five for the criterion of grades and two for the criterion of absences. In contrast to these two studies involving simple correlational analyses of data collected from samples of limited size, Moos (1979) has reported a more comprehensive and stringent investigation of environment-outcome relationships involving the use of multiple regression techniques with data from a sample of 241 classes. The outcomes consisted of five indexes of student reactions (friendship formation, sense of well-being, satisfaction with learning, satisfaction with teachers, alienation), and outcome-environment relationships were estimated after removing the variance in outcomes attributable to five other domains of predictors (e.g., student characteristics and teacher characteristics). Specific findings included that a block of classroom environment variables (based on cluster analysis of CES scores) uniquely explained half of the predictable variance in student satisfaction with the teacher, and that students in supportive task oriented and supportive competition oriented classes showed the most positive reactions on the outcome criteria (including satisfaction with learning).

Although the CES has been used to a limited degree in previous research on the effects of psychosocial characteristics of the classroom environment on student learning outcomes, there has been a sizable number of studies using alternative instruments. These include the use of the Learning Environment Inventory in studies in the U.S.A. (Lawrenz, 1976; Walberg, 1972), Canada (O'Reilly, 1975; Walberg & Anderson, 1972), Australia (Fraser, 1979; Power & Tisher, 1979), Israel (Hofstein, Gluzman, Ben-Zvi, & Samuel, 1979), and India (Walberg, Singh, & Rasher, 1977), the use of the My Class Inventory in the U.S.A. (Talmage & Walberg, 1978) and Australia (Fisher & Fraser, 1981), and the use of the Individualized Classroom Environment Questionnaire in Australia (Rentoul & Fraser, 1980). Taken together, prior research results

provide convincing and consistent evidence that students' classroom environment perceptions account for appreciable amounts of variance in learning outcomes, often beyond that attributable to student characteristics such as pretest performance, general ability, or both (see Anderson & Walberg, 1974; Fraser, 1981a; Walberg & Haertel, 1980). Moreover, this pattern is further highlighted in the results of Haertel, Walberg, and Haertel's (1981) recent meta-analysis involving 734 correlations obtained from 12 studies of 10 data sets in eight subject areas, encompassing 17,805 students in 823 classes in four nations. This research synthesis revealed strong and consistent associations between student cognitive and affective outcomes and their perceptions of classroom environment.

Design of Present Study

In order to permit investigation of relationships between classroom environment perceptions and learning outcomes in the present study, three cognitive and six affective measures were administered both at the beginning and end of the same school year. The three cognitive outcomes were measured by the Test of Enquiry Skills (Fraser, 1979b) and consisted of ten-item, multiple choice scales called Comprehension of Science Reading, Design of Experimental Procedures, and Conclusions and Generalizations. The KR-20 reliability figures for class means were found to be 0.81, 0.75, and 0.77, respectively, for the present sample of 116 classes. The six attitude measures each consisted of ten items of Likert format and were selected from the Test of Science-Related Attitudes (Fraser, 1981c). These scales are called Attitude to the Social Implications of Science, Enjoyment of Science Lessons, Attitude to the Normality of Scientists (i.e., the extent to which students view scientists as normal people rather than as the eccentrics sometimes depicted in the mass media), Attitude to Inquiry, Adoption of Scientific Attitudes (e.g., curiosity, open-mindedness), and Leisure Interest in Science.

Class alpha reliabilities were found to range from 0.80 to 0.97 for these six attitude scales. In addition to these cognitive and affective measures, information was gathered about the general ability of the students using a version of the Otis test.

The present study involved the use of the class mean as the unit of statistical analysis. Also, in order to permit easier comparison of the results of this study with prior research, data were analyzed in six different ways which reflect major methodological variations in past research. These six methods - namely a simple, multiple, and canonical correlational analysis involving raw scores and a simple, multiple, and canonical correlational analysis involving residual scores - are discussed and clarified below.

It has been common in prior research to perform a conservative test of outcome-environment relationships by controlling statistically certain student characteristics, especially corresponding pretest and general ability. That is, for reasons of simplicity, learning environment dimensions have been considered useful predictors of student learning outcomes only if they accounted for different variance from that attributable to well-established predictors like pretest and general ability. While conservative analyses in which student characteristics are controlled have the merit that they do not overestimate the variance component attributable to environment, they might well underestimate the importance of the environment component because any variance shared by environment and student characteristics is removed. For this reason, all analyses (simple, multiple, canonical correlation) were performed twice, once using raw posttest scores as the criterion variables and once using residual posttest scores adjusted for corresponding pretest and general ability.

Table III shows the results of the six types of analyses. The first pair of analyses shown in this table are the least complex as they involve simple correlations between class means on the nine CES scales and class means

on the set of nine outcome posttests (using either raw scores or residual scores adjusted for corresponding pretest and general ability). A major advantage of these simple correlational analyses is that they furnish data to other workers interested in associations between particular environment variables and particular outcomes. For example, future workers wanting to conduct meta-analyses involving specific environment or outcome variables would require this sort of data. The results in Table III show that the number of significant outcome-environment correlations ($p < .05$) was 27 for the analysis involving raw posttest scores (i.e., about seven times that expected by chance) and 18 for the analysis using residual posttest scores (about four times that expected by chance). Furthermore, inspection of the signs of the correlations in Table III show that all significant outcome-environment relationships were positive except for three cases in which greater levels of perceived Innovation were associated with lower raw outcome scores (Attitude to the Normality of Scientists, Design of Experimental Procedures, and Conclusions and Generalizations).

The second pair of analyses reported in Table III consisted of a multiple correlation analysis involving the set of nine CES scales, and performed separately for each outcome using either raw or residual criterion scores. The multiple correlation provides a more parsimonious picture of the joint influence of correlated environment dimensions on outcomes, and reduces the Type I error rate associated with simple correlational analysis. These analyses should be of particular relevance to people interested in specific outcome measures. Table III shows that the multiple correlation between raw outcome scores and the set of classroom environment scales ranged from 0.30 to 0.51 and was significantly greater than zero ($p < .05$) for seven of the

Table III. Simple, Multiple, and Canonical Correlations Between Classroom Environment Dimensions and Learning Outcomes (Using Raw Outcome Scores and Residual Scores Adjusted for Corresponding Pretest and General Ability)

Learning Outcome	Raw Scores/ Residuals[a]	Simple Correlation									Multiple Correlation	Beta Weights for Significant Individual Environment Predictors[b]
		Involv	Affil	Teach Supp	Task Orien	Comp	Order & Org	Rule Clar	Teach Contr	Innov		
Social Implications of Science	Raw Scores	.22*	.16	.16	.25**	.20*	.30**	.24*	.02	.06	.38*	.34* (Order & Org)
	Residuals	.27**	.24*	.15	.25**	.14	.33**	.26**	.03	.09	.39*	.36* (Order & Org)
Enjoyment of Science Lessons	Raw Scores	.42**	.20*	.27**	.17	.13	.45**	.25**	-.02	.20*	.49**	.43** (Order & Org)
	Residuals	.36**	.27*	.16	.22*	.02	.40**	.20*	.05	.03	.44**	.38* (Order & Org)
Attitude to Normality of Scientists	Raw Scores	.12	.10	.07	.23*	.03	.16	.10	.08	-.20*	.39*	.37* (Teach Supp); -.37** (Innov)
	Residuals	.17	.11	.15	.07	-.04	.10	.18	.08	-.04	.31	
Attitude to Inquiry	Raw Scores	.11	.18	.05	.18	.07	.10	.23*	.07	.03	.38*	.25* (Rule Clar)
	Residuals	.10	.18	.04	.13	.05	.09	.23*	.09	.01	.29	
Adoption of Scientific Attitudes	Raw Scores	.07	.29**	.10	.25**	.14	.17	.06	-.04	-.13	.44**	.27* (Affil); -.26* (Innov)
	Residuals	.16	.26**	.21*	.07	-.01	.18	.15	-.02	.06	.30	.23* (Affil)
Leisure Interest in Science	Raw Scores	.28**	.22*	.11	.25**	.08	.41**	.25**	.04	.20*	.51**	.56** (Order & Org); .31** (Innov)
	Residuals	.30**	.12	.11	.12	-.11	.35**	.21*	.00	.23*	.49**	.45** (Order & Org); .32* (Innov)
Comprehension of Science Reading	Raw Scores	.02	.13	-.03	.15	.05	.13	-.05	-.04	-.13	.30	
	Residuals	.11	.13	.00	.03	.03	.17	.06	.06	.01	.27	
Design of Experimental Procedures	Raw Scores	-.08	.03	-.06	.22*	.18	.11	.01	.05	-.20*	.37	
	Residuals	-.05	-.05	-.02	-.05	.09	.05	.09	.12	-.05	.28	
Conclusions and Generalizations	Raw Scores	.08	.17	.06	.31**	.15	.22*	-.02	.04	-.20*	.47**	(.35* (Teach Supp); .27* (Task Orien); (-.28* (Innov)
	Residuals	.18	.12	.07	.14	.07	.26**	.07	.12	-.02	.38**	.35* (Order & Org)
Canonical Correlations	Raw Scores										.67**, .54**	
	Residuals										.62**	

*$p < .05$, **$p < .01$

[a] Residual scores have been adjusted for performance on the corresponding pretest and general ability.

[b] Beta weights are shown for those individual predictors for which, first, the corresponding block of nine environment scales had a significant multiple correlation and, second, the b weight was significantly different from zero.

nine outcomes. As expected, multiple correlations were smaller for analyses involving residual scores, with values ranging from 0.27 to 0.49 and with four of these being statistically significant.

In order to interpret which individual CES scales were making the largest contribution to explaining variance in learning outcomes, an examination was made of b and beta weights for those regression equations for which the multiple correlation for the whole block of nine environment scales had been found to be significantly greater than zero ($p < .05$). The right hand side of Table III lists the magnitude of the beta weight for those individual environment scales whose b weight was significantly different from zero ($p < .05$) and for which the corresponding block of environment scales also had a significant multiple correlation. This table shows that a number of significant relationships for individual environment variables was 11 when raw criterion scores were used and was 5 when residual criterion scores were used.

The signs of the beta weights in Table III can be used to suggest the following interpretations for the 11 significant individual outcome-environment relationships using raw posttest scores: Social Implications of Science scores were higher in classes perceived as having greater Order and Organization; Enjoyment of Science lessons scores were higher in classes perceived as having greater Order and Organization; Attitude to the Normality of Scientists scores were higher in classes perceived as having greater Teacher Support and less Innovation; Adoption of Scientific Attitude scores were higher in classes perceived as having greater Affiliation and less Innovation; Leisure Interest in Science scores were higher in classes perceived as having greater Order and Organization and Innovation; and Conclusions and Generalizations scores were higher in classes perceived as having greater Teacher Support, greater Task Orientation, and less Innovation. Examination of the signs of the beta weights for residual scores in Table III suggests the following interpretations of significant outcome-environment relationships

when corresponding pretest and general ability were controlled: greater levels of perceived Order and Organization in the classroom were associated with higher scores on Social Implications of Science, Enjoyment of Science Lessons, Leisure Interest in Science, and Conclusions and Generalizations; and greater levels of perceived Innovation were associated with higher Leisure Interest in Science scores.

Although the use of the multiple correlation analyses overcomes the problems of collinearity between CES scales, collinearity between outcome measures could still give rise to an inflated experimentwise Type I error rate. Canonical analysis, however, can provide a parsimonious picture of relationships between a domain of correlated learning outcomes and a domain of correlated environment dimensions. Consequently, two canonical analyses were conducted using the class mean as the unit of analysis. Whereas the first canonical analysis explored relationships between scores on the set of nine environment scales and raw posttest scores on the set of nine learning outcomes, the second canonical analysis explored relationships between scores on the set of nine environment scales and residual posttest scores on the nine learning outcomes. The bottom of Table III shows that both canonical analyses yielded at least one significant canonical correlation. Two significant canonical correlations of 0.67 ($p < .01$) and 0.54 ($p < .05$), respectively, were found between environment scales and raw posttest scores, while one significant canonical correlation of 0.62 ($p < .01$) was found between environment scales and residual posttest scores.

In order to interpret the results of the canonical analyses, an examination was made of the magnitudes and signs of canonical loadings associated with each significant canonical variate. The interpretation of the first significant canonical correlation for the analysis involving raw scores was readily interpretable. It indicated that attitude scores on the Enjoyment of Science Lessons and Leisure Interest in Science scales were higher in classes perceived

as having greater Order and Organization and Innovation. The interpretation of the second significant canonical correlation for the analysis of raw scores was less straightforward, but it suggested that cognitive outcome scores on the Conclusions and Generalizations scale tended to be higher in classes perceived as having more Teacher Support and less Innovation. These interesting but tentative results for the two canonical variates for the present sample suggest that classroom Innovation tended to enhance attitudinal outcomes but to impede cognitive outcomes. The straightforward interpretation of the significant canonical correlation for residual scores was that, with corresponding pretest scores and general ability controlled, Leisure Interest in Science scores were greater in classrooms perceived as having greater Order and Organization.

CONCLUSION

This paper has described a study of relationships between students' learning outcomes and their perceptions of classroom environment as measured by the Classroom Environment Scale (CES) among a large sample of 1,083 students in 116 classrooms. It was found that, for this sample, CES scales displayed satisfactory internal consistency and discriminant validity, and that each scale differentiated significantly between the perceptions of students in different classrooms. Relationships between a set of nine learning outcomes (six affective and three cognitive) and the set of nine classroom environment scales contained in the CES were explored using the class mean as the unit of analysis and six different data analytic techniques. Three of these were a simple correlational analysis between raw scores on outcome posttests and CES scales, a multiple correlational analysis involving the prediction of raw scores on each outcome posttest from the set of nine CES scales, and a canonical analysis involving the set of nine CES variables and raw scores on the set of nine outcome posttests. The other three analyses were analogous

to these and consisted of simple, multiple, and canonical analyses involving the set of nine CES scales and residual scores on the set of nine outcome posttests (adjusted for corresponding pretest and general ability). Taken together, the six different analyses confirmed the existence of sizable and statistically significant associations between students' learning outcomes and their classroom environment perceptions as measured by the CES.

The general finding of the existence of significant environment-outcome relationships which emerged from the present use of the CES replicates many prior science education studies (see review of Fraser & Walberg, 1981) which have established appreciable relationships between classroom environment and student outcomes in studies involving a variety of instruments in numerous different countries. Furthermore, it is possible to compare the present specific findings with those of Haertel, Walberg and Haertel's (1981) recent meta-analysis of 12 past studies which, although not involving use of the CES specifically, involved several scales analogous in meaning to some of the CES's scales. In particular, the present results indicating that student outcomes were enhanced in classes with greater Affiliation, Task Orientation, and Order and Organization replicate some of the findings emerging from this meta-analysis. Also, it is noteworthy that the proportion of significant correlations emerging between affective outcomes and classroom environment variables classifiable as Relationship dimensions (i.e., Involvement, Affiliation, and Teacher Support) was greater than the proportion of significant correlations elsewhere in the outcome-environment correlation matrix (see Table III). This pattern of results is consistent with Moos's (1979) general contention that Relationship dimensions influence attitudes, and supports the general usefulness of Moos's (1974b) scheme for classifying the types of dimensions characterizing human environments.

Because of the correlational nature of the present study and most prior research, caution should be exercised in assuming that the nature of the classroom environment "caused" student outcomes. Admittedly the fact that the present results replicate prior research increases confidence in the findings, and the use of residual scores (adjusted for corresponding pretest and general ability) rules out the major rival hypothesis that observed outcomes could be attributed to differences in student background characteristics found in classes with different environments. Consequently, a desirable direction for future research would be to conduct controlled intervention studies in which the nature of classroom environments are deliberately manipulated in order to permit investigation of whether changing classrooms in specified directions does result in hypothesized improvements in students' attitudes and achievements.

One practical implication emerging from this study is that researchers and teachers can have greater confidence in using the CES. The present study showed that the CES scales displayed satisfactory reliability when used for the first time specifically in science classes. Also the establishment of empirical links between desired student outcomes and classroom environment characteristics has practical implications about ways in which science teachers might change their classrooms to improve student attitudes and achievements. In particular, the present study suggests that emphasis on classroom Order and Organization is likely to have a positive influence on student achievement of a wide variety of different aims. It is hoped that science educators will make use of the CES for a variety of worthwhile purposes including monitoring and evaluating curriculum innovations (Fraser, 1981a), investigating differences between science students and teachers in their perceptions of actual and preferred

classroom environment (Fisher & Fraser, in press), exploring whether students achieve better when in their preferred classroom environment (Fraser & Fisher, in press), and attempting to use student perceptions as a practical basis for guiding environmental change (Fraser, 1981d).

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